[Handle for Hand and Garden Tools, as well as Handle-and-Tool Sets Containing such Handles]

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HANDLE FOR HAND AND GARDEN TOOLS, AS WELL AS HANDLE-AND-TOOL SETS CONTAINING SUCH HANDLES

The invention pertains to handles for hand and garden tools according to the preamble of Claim 1, as well as to handle-and-tool sets containing such handles.

In the context of the present invention, the term handles for hand and garden tools refers to handles that cause a preferred coupling position of the hand when the tool is used, i.e., the user preferably takes hold of and encloses the handles with a specific hand position that depends on the handling of the tool while it is used, wherein this hand position changes only insignificantly while the tool is being used. This pertains, in particular, to handles that are centered in the hand cavity approximately in the center of their longitudinal extent while the tool is used. Until now, handles of this type were manufactured in preselected groups and shapes depending on the intended use of the respective tool, e.g., a handsaw or a file, and designed differently by the various manufacturers. These designs are frequently realized in accordance with given standards. In the product assortment of a manufacturer, only one respective handle is available for a tool of a certain type and size. This applies, in principle, independently of whether the tools have a one-part handle, e.g., for hammers, firmer chisels, files, mason=s trowels, saws or the like, or a two-part handle, e.g., for pliers, pruning shears or similar tools of the plier or scissor family.

The design of the handles as a function of the intended use of the respective tool should be done in accordance with ergonomic considerations, particularly if the tools are used professionally. This is the reason why it has already been investigated which coupling position the hands should assume relative to the handles and which dimensions ergonomically favorable handles should have [e.g., "Ergonomic Tool Design, Systematic" (Research Report No. 156), published by the German Federal Institute for Occupational Safety and Accident Research in 1979]. It is surprising that these investigations did not result in handles that sufficiently take into account the anatomical peculiarities of the quite different sizes and/or shapes of the human hand. For example, a barrel shape with a curvature radius of 220 mm for the longitudinal contour is proposed for grab handles (page 253). A curvature radius of 220 mm is also proposed for plier-like handles. These radii are too large, and do not result in an optimal contact between the handles and the hand. Handles that are known from the prior art and are available on the market also have not undergone additional developments. For example, hammer handles do not fill up the hand cavity, and are even partially shaped in a concave fashion within the contact region such that, in particular, the recoils occurring while hammering are distributed over small and limited zones of the hand. Although saw handles are shaped in a convex fashion in the longitudinal direction, the curvature radii are too large, and possibly-provided depressions for the fingers are not appropriately designed. Although pliers frequently have convex or elliptical handle parts in

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the longitudinal direction, most handles are too narrow and excessively short such that the outer edges of the palm do not contact the handles, and the inner surface of the hand, as well as the middle joints of the fingers, are subjected to painful pressure in a narrow zone when the pliers are closed. The handles of firmer chisels (wood chisels) usually extend in a continuously conical or even concavely curved fashion in the longitudinal direction. This completely contradicts the anatomy of the encompassing hand. Corresponding and additional deficiencies can also be observed with all the tool handles.

Not in case

Handles of the initially described type are explained in detail in prior applications of the same applicant (PCT/DE 00/00209 of January 25, 2000 and DE 199 02 882.6 of January 25, 1999). Handles of this type should automatically cause a preferred coupling position of the hand while the respective tool is used, and also make it possible to largely standardize the handles in accordance with different handle sizes and/or handle shapes. The essential elements of such handles are the respective center parts, the upper and lateral sections of which are shaped such that they assume a centered position in the hand cavity while the tool is being used, and essentially fit closely against the entire inner surface of the hand. However, the above-mentioned older proposals do not contain any specific information concerning which handles dimensions need to be influenced in order to achieve the desired effect. This also applies to other known handle (PCT-WO 98/29167) which have certain curvatures that fit into the hand cavity and are, in particular, characterized by special support surfaces for the thumb and trough-like receptacles for the remaining four fingers.

Based on the aforementioned circumstances, the invention aims to further improve handles of the initially described type and to disclose those dimensions of the handles which most easily result in a preferred coupling position of the hand and are suitable for a comprehensive standardization. However, the handles are neither individually adapted to certain hands nor designed for an "average hand." On the contrary, the invention aims to sort and classify measuring data obtained from hand measurements such that groups of hand sizes can be formed therefrom.

This objective is attained with the characteristics disclosed in the characterizing portions of Claims 1, 28, 30 and 31.

Other advantageous characteristics of the invention are disclosed in the subclaims.

The invention is described in greater detail below with reference to the embodiments that are illustrated in the enclosed figures. The figures show:

Figures 1 and 2, a schematic perspective representation and a schematic top view of a section of an oval handle known from the prior art, used to explain the terms used in the following description;

Figure 3, a schematic representation of the inner surface of a right hand, used to illustrate the hand sections that are important for the invention;

Figure 4, a cross section through the hand along the line IV-IV in Figure 3;

Figure 5, a side view of a handle according to the invention for a hand tool in the form of a hammer;

Figure 6, a top view of the handle shown in Figure 5;

Figures 7-10, cross sections through the handle along the lines A-A, B-B, C-C and D-D in Figures 5 and 6;

Figure 11, a schematic side view of the handle according to Figures 5-10 in connection with a hammer, and a hand that encompasses the handle and is situated in a preferred coupling position;

Figures 12 and 13, schematic sections along the lines XII-XII and XIII-XIII in Figure 11;

Figures 14-18, representations of a second embodiment of a hammer handle according to the invention which correspond to the representations in Figures 5-9;

Figures 19-24, representations of a handle according to the invention for a hand tool in the form of a mason=s trowel which correspond to the representations in Figures 5-10;

Figures 25-30, representations of a second embodiment of a handle according to the invention for a mason=s trowel which correspond to the representations in Figures 19-24;

Figures 31 and 32, schematic side views of the handles according to Figures 19-24 and Figures 25-30, respectively, with a hand that encompasses the handle and is situated in a preferred coupling position;

Figure 33, a schematic side view of a handle according to the invention for a hand tool in the form of a saw;

Figure 34, a front view of the handle according to Figure 33 (viewed from the right in Figure 33);

Figures 35-37, cross sections through the handle along the lines A-A through C-C in Figure 33;

Figures 38 and 39, schematic side views of the handle according to Figure 33 in connection with a hand that encompasses said handle, with the hand still being partially open in Figure 38 and situated in a preferred coupling position in Figure 39;

Figures 40-43, schematic longitudinal sections through a handle according to the invention that, in particular, is suitable for a mason=s trowel, along four different sectional planes that are respectively rotated by 45°;

Figures 44a and 44b, cross sections through the handle along the lines A through T in Figure 40;

Figure 45, a schematic representation of the position of the x, y and z coordinates of selected points on the surface of the handle according to Figure 40;

Figure 46, a perspective grid representation of a handle that essentially corresponds to Figures 40-45;

Figure 47, a side view of the handle according to Figure 46 which corresponds to the side view shown in Figure 5, in the form of a grid representation;

Figures 48-50, a top view, another side view after turning the handle in Figure 47 by 90° and a bottom view after turning the handle according to Figure 47 by 180°, wherein the handle is rotated in the clockwise direction;

Figure 51, a side view of a handle according to the invention for a hand tool in the form of pliers;

Figure 52, a top view of the handle according to Figure 51;

Figures 53-55, sections along the lines A-A through C-C in Figure 51;

Figure 56, a schematic representation of the handle according to Figure 51 in connection with a hand situated in a semi-open position;

Figure 57, a representation of a hand, situated in a preferred coupling position, that corresponds to the representation in Figure 56;

Figure 58, a representation of the handle according to Figure 51, essentially corresponding to the representation in Figure 13, with a hand that encompasses the handle and is situated in a preferred coupling position;

Figures 59-63, representations of a second embodiment of a plier handle according to the invention that correspond to the representations in Figures 51-55;

Figures 64 and 65, representations of a third embodiment of a plier handle according to the invention that correspond to the representations in Figures 51 and 52;

Figures 66-69, schematic longitudinal sections through a handle according to the invention which is, in particular, suitable for a hammer, along four different sectional planes that are respectively rotated by 45°;

Figure 70, cross sections through the handle along the lines A through L in Figure 66;

Figures 71-73, grid representations of the handle according to Figures 66-70 that correspond to the grid representations in Figures 47-50;

Figure 74, a perspective dot matrix representation of the handle according to Figure 71;

Figures 75-83, representations of a handle according to the invention that is particularly suitable for a saw, with said representations corresponding to the representations in Figures 66-74;

Figures 84-92, representations of a section of a handle according to the invention that is suitable for pliers, with said representations corresponding to the representations in Figures 66-74;

Figures 93a and 93b, tables with dimensions for a preferred embodiment of the handle according to Figures 14-18;

Figures 94a and 94b, tables with dimensions for a preferred embodiment of the handle according to Figures 19-24;

Figures 95a and 95b, tables with dimensions for a preferred embodiment of the handle according to Figures 34-37, and

Figures 96a, 96b and 96c, tables with dimensions for a preferred embodiment of the handle according to Figures 51-55.

Figures 1 and 2 schematically show, in the form of an enlarged representation, part of a conventional handle 1 that essentially extends in a continuously oval fashion in the longitudinal direction and is, for example, situated on the end of the shank of a hammer. An axis that is respectively defined by the largest diameter in the cross section represents the x-axis, an axis that is respectively defined by the smallest diameter represents the y-axis, and a central axis or longitudinal axis that extends perpendicular to the two aforementioned axes represents the z-axis. In addition, the height of the handle 1 is measured in the direction of the x-axis (dimension H), the thickness of the handle 1 is measured in the direction of the y-axis (dimension D), and the length of the handle 1 is measured in the z-direction (dimension L). It is also assumed that the handle 1 is divided into a first outer handle section 7, a second outer handle section 8 and a third handle section 9 that lies between the two aforementioned handle sections and represents an inner handle section bounded by two imaginary surfaces 5, 6 that are illustrated with broken lines and, for example, extend parallel to the zy-plane. These three handle sections lie adjacent to one another in the direction of the x-axis. This means that the first handle section 7 has a first outer surface 10 that includes a first zone with small curvature radii, and that the second handle section 8 has a second outer surface 11 that is situated diametrically opposite to the first outer surface and includes a second zone with small curvature radii. By contrast, the third section 9 has two diametrically opposed surfaces, namely third and fourth outer surfaces 12 and 13, with large curvature radii. These surfaces 12 and 13 respectively extend approximately up to the intersection lines with the corresponding boundary surfaces 5 and 6 that are indicated by the points 14, 15 and 16, 17, and represent continuations of the contours formed by the surfaces 10 and 11. This means that the entire outer surface contour has a continuously elliptical or oval cross section. It is also assumed that the handle section 7 corresponds to the hand cavity of right-handed users, and that the surfaces 10-13 make contact with associated hand and finger regions. The handle 1 is, for example, realized in the form of a one-piece handle and is quite

massive, with said handle being suitable, for example, for a hammer, a mason=s trowel or the like. In this case, the height of the handle section 9 may approach zero. However, if the handle consists of a handle for pliers, which conventionally comprises two pivoted handle limbs, it can be assumed for the purpose of the invention that one handle limb is essentially realized by the section 7 in Figures 1 and 2, and that the other handle limb is essentially realized by the handle section 8, wherein the inner section 9 is in this case omitted. If viewed in the direction of the x-axis, the sections 7 and 8 are spaced apart from one another by a distance that in this situation depends on the type of tool. The height, the thickness and the length of such two-part handles in the x-, y- and z-direction are indicated, analogously to Figures 1 and 2, by the dimensions H, D and L, or are determined from distance vectors as described in detail below. In the ensuing figures, the boundary surfaces that divide the individual sections are at least partially indicated by broken lines, but are not mentioned further in other respects.

The parts of a right hand 19 that are important for explaining the invention are illustrated in Figure 3. According to this figure, the hand 19 contains a thumb 20 with a proximal thumb joint 21 near the hand 19 and a distal thumb joint 22 that is situated distant from the hand 19, as well as the other four fingers that respectively comprise proximal, central and distal finger joints 23, 24 and 25. The hand 19 also comprises a thumb saddle 26 between the thumb 20 and the index finger, an edge of the finger root 27, a ball of the thumb 28, a ball of the hand root 29 and a hand edge 30 with a ball of the hand edge 31. The part at which the fingers begin is referred to as the ball of the finger root 32, and the part circumscribed by the balls 28, 29, 31 and 32, as well as the thumb bridge 26, is referred to as the inner surface of the hand or simply the palm 33. In the preferred coupling position, this palm is deformed into a characteristic hand cavity about a center point 34.

According to Figure 3, the hand width is measured between the hand edge 30 and the diametrically opposite edge of the finger root 27 in the vicinity of the thumb bridge 26, while the hand 19 is stretched out. This dimension is measured transverse to the longitudinal axis of the hand 19 as indicated by a line B in Figure 19.

Figure 4 shows a schematic section through the hand surface 33 along the line IV-IV in Figure 3, with a schematically arranged handle 1 according to Figure 1. This indicates that conventional oval handles 1 do not fulfill the ergonomic requirements because they only contact the hand in the region of the palm 33 at narrow areas of the thumb bridge 26 or the ball of the thumb 28, and at the ball of the hand edge 31, with the handle not contacting the palm 33 in the regions situated in between.

Figures 5-10 show a handle 38 according to the invention that is, for example, suitable for a hammer. This handle is largely adapted to the hand 19 according to Figures 3 and 4, and is preferably manufactured in one piece. The handle 38 has a longitudinal axis 39 that essentially

corresponds to the central axis of the handle 38 in this case. In the direction that extends perpendicular to the longitudinal axis, the handle has cross-sectional surfaces that are essentially egg-shaped, elliptical or oval at all locations (Figures 7-10).

The longitudinal axis 39 may, for example, extend through the center points of circular end faces that are arranged on the ends of the handle 38, with the longitudinal axis being arranged coaxial with the central axis of a receptacle opening that is intended to accommodate a tool shaft, or it can be defined in some other way in the central handle region. According to the aforementioned definitions regarding Figures 1 and 2, the longitudinal axis forms the z-axis of an imaginary cartesian coordinate system. In sectional planes that are arranged perpendicular to the longitudinal axis 39 (e.g., Figures 7-10), the axes extending through the largest diameter respectively lie parallel to the x-axis, and the axes extending through the smallest diameter lie parallel to the y-axis of the imaginary coordinate system. This also produces the dimensions H and D. The dimensions measured in the direction of the z-axis are referred to in this case as the distances between predetermined cross-sectional planes. The dimensions H and D of the handle 38 have different values along the longitudinal axis 39.

In Figures 5 and 8, it is assumed that the handle 38 is divided into three sections 42-44 by two planes 40 and 41 that are indicated with broken lines, and each lie on one side of the yz-plane and parallel thereto. The sections 42 and 43 correspond to the sections 7 and 8 in Figures 1 and 2 and are referred to as the upper section 42 and the lower section 43 in accordance with their position above and below the yz-plane. However, the section 44 that corresponds to the section 9 in Figures 1 and 2 is referred to as the inner section. The handle 38 is also limited on its distal end, is coupled to a functional part of the corresponding tool and lies on the left in Figures 5 and 6, as well as on its opposite proximal end, by respective planes 45 and 46 arranged perpendicular to longitudinal axis 3a (Figure 5), such that the distance between the planes 45, 46 represents the total length of the handle. Between these planes 45, 46 respectively extend one distal endpiece 48 that borders on the plane 45 and extends up to a cross-sectional plane 47, a distal part 50 that borders thereon and extends up to a cross-sectional plane 49, a center part 52 that borders thereon and extends up to a cross-sectional plane 51, a proximal part 54 that is situated adjacent thereto and extends up to a cross-sectional plane 53, and ultimately a proximal endpiece 55 that borders on the plane 46. It should be clarified that all these parts are assumed to be divided into respective upper, lower and inner or central sections by the planes 40, 41 (Figure 8), with the respective upper, lower and inner or central sections forming the sections 42-44. Although the handle 38 may also be realized as hollow in its interior, it is preferably solid.

The surfaces of the upper, lower and inner sections 42-44 have the contours shown in Figures 5 and 6 and the cross-sectional shapes shown in Figures 7-10, with the surfaces of the different parts or sections respectively transforming into one another in an essentially smooth

fashion. The cross section of the handle 38 has the egg shape shown in Figures 7-10. The center part 52 respectively has—if viewed in the form of a longitudinal section—a surface contour that is designed in a more or less convex fashion over at least part of the circumference of the upper section 42. The distal part 50 and the proximal part 54 essentially have a concave surface contour that also extends over at least part of the circumference of the upper section 42. In this embodiment, all surface contours are designed to be convex or concave as can be ascertained, in particular, from a comparison between Figures 5 and 6 and Figures 7-10. The cross sections in Figures 7-10 also indicate that the height H and the thickness D of the handle 1 are greater in the center part 52 than in the distal part and the proximal part 50 and 54. This means that a surface contour that extends in a concave-convex-concave fashion, along the longitudinal direction in the top view according to Figure 6, results. For example, in a body that is rotationally symmetrical about the longitudinal axis 39, a concave-convex-concave line 56 in Figure 6 would represent a generatrix of the rotational surface of this body.

The distal endpiece 48 is realized analogously to conventional collars that prevent the hand from sliding off the handle, and is less important for the purpose of the invention. The distal endpiece may also be entirely omitted, with the proximal endpiece 55 having the shape of a more or less defined hemispherical cap, and also being less important for the purpose of the invention.

In a handle for right-handed users, the center part 52 in the upper section 42 is, according to the invention, realized such that it fits closely against the inner surface 33 of the hand 19 (Figure 3) of the user while the handle 38 is being used and is situated in the hand cavity. Consequently, the center part 52 in the upper section 42 is provided with a curvature 57 (Figure 8) that is distinctly directed radially outward and is pronounced in at least two directions that extend perpendicular to one another. This curvature extends over at least part of the circumference of the upper part 42 and is produced due to the convex surface contour. When viewed from the distal end, the curvature of the handle 38 for right-handed users lies on the left side of the xz-plane.

The distal part 50 in the upper section 42 is designed to be encompassed by the saddle between the thumb 20 and the index finger (Figure 3). This is why this region is, analogously to Figure 5, provided with a concave surface structure that also extends over at least part of the circumference of the upper part 42. By contrast, the proximal part 54 in the upper section 42 is designed to contact the ball of the hand root 29 (Figure 3). In accordance with Figures 5 and 6, this region also is designed in a concave fashion over at least part of the circumference of the upper part 42.

The surface contour of the lower section is preferably shaped as required for the encircling by the finger joints which occurs at this location, and for the trapezoidal inner contour of the encircling fingers in a preferred coupling position of the hand.

The surfaces of the inner section 44 that correspond to the surfaces 12 and 13 in Figure 2 serve to connect the sections 42 and 43 as shown in Figures 7-10. They may contain corresponding concave and convex surface contours in the longitudinal direction (z-axis) which transform into the contours of the surfaces of the sections 42 and 43 in a smooth fashion.

The concave and convex surface contours can be defined by curvature radii R1.1-R3.4 (Figures 5 and 6). For the purposes of the present invention, those curvature radii are of particular importance that occur in the upper section of the center part 52 at the maximum or summit 59 of the convex surface contour (sectional plane B-B in Figure 5), and in the upper sections of the distal and the proximal parts 50, 54 at the respective minimums 60 and 61 of the concave surface contour (sectional planess A-A and C-C in Figure 5). A comparison between Figures 5 and 6 shows that the cross-sectional planes that extend through these maximum 59 and minimums 60, 61 respectively have a different axial position in the upper section 42 than in the lower section 43 (for example, the maximum 62 in Figure 5).

The curvature radii R2.1-R2.4 that are particularly important for the purpose of the invention and would, in Figure 8 in which they are not shown, lie on the top, the left, the bottom and the right in the coordinate system shown if it were turned to the left by 90°, approximately define respective sections of a circular arc that lie in the xz-plane (Figure 6) in Figures 5 and 6. These sections of the circular arc may, viewed in the direction of the z-axis, extend over a longer distance with an essentially constant curvature radius (e.g., R2.1) to both sides of the maximums (e.g., 59) before this curvature radius gradually decreases and the surface contours of the center part 52 ultimately transform into the concave surface contours of the parts 50, 54 at turning points. This not only applies to the four contour lines with the radii R2.1-R2.4 which are shown in Figures 5 and 6 and respectively lie in the xz-plane and the yz-plane, but also to the other planes that include the z-axis. For example, the turning points of the contour line extending through the maximum 59 are defined in Figure 5 by the position of the cross-sectional planes 49 and 51. The transition between the regions identified by the curvature radii R2.1-R2.4 are respectively defined by analogous radii or curves that, depending on practicality, may deviate from the radii R2.1-R2.4. The concave regions with the curvature radii R1.1-R1.4 and R3.1-R3.4 preferably progress accordingly.

The egg-shaped cross-sectional surfaces in Figures 7-10 can be defined by radii RA.10-RC.13. The curvature radii RA.10, RB.10 and RC.10 which respectively occur in the region of the sectional planes A-A through C-C, as well as in the maximum 59 and in the minimums 60, 61 in the upper sections, are of particular importance for the purpose of the present invention. In addition, the radii RA.10-RA.13, RB.10-RB.13, etc, according to Figures 7-10 respectively lie in planes that extend parallel to the xy-plane, if turned to the left by respective angles of 90° in the imaginary coordinate system. In this case, the letters A, B, and

C etc., indicate the sectional planes A-A, B-B, C,-C etc., in Figure 5. Consequently, the aforementioned radii define sections of the circular arc which lie in these planes. Analogously to the radii R1.1-R3.4, the sections of a circular arc which belong to the radii RA.10-RC.13 may, when viewed in the planes that lie parallel to the xy-plane, extend over longer arc sections with essentially constant curvature radii on both sides of the maximums and minimums (e.g., 59 in Figure 8). The transitions between the regions identified by these radii are respectively defined by analogous radii or curves that, depending on practicality, may also deviate from the radii RA.10-RC.13. Similar observations can be made in an arbitrary number of additional cross-sectional planes along the longitudinal axis 39.

In the longitudinal direction, the distances L0.1, LI.1, LII.1 and LIII.1, which are shown in Figure 5 and are described in greater detail below, are of particular importance for the handle 38. The reference plane for these dimensions is the sectional plane B-B that extends through the upper maximum 59 that lies in the xz-plane and otherwise lies parallel to the xy-plane, i.e., the maximum 59 on the upper side of the upper section 42 unequivocally defines the position of the reference plane 63. Its distance from the planes that extend through the minimums 60, 61 is defined, respectively, by the dimensions LI.1 and LII.1, wherein LIII.1 represents the distance of the reference plane 63 from the proximal end of the proximal part 54 (plane 53) of the handle 38. Corresponding dimensions LI.2-LI.4, LII.2-LII.4 and LIII.2-LIII.4 can be used to indicate the distances of the reference plane 63 from other minimums that, for example, are associated with the radii R1.2-R1.4 and R3.1-R3.4 in Figures 5 and 6 (for example, see LI.4 and LII.4 in Figure 6). A dimension LIV.2 indicates, for example, the distance of the maximum 62 from the reference plane, wherein this distance may also be equal to zero, namely if the maximum 62 also lies in the reference plane 63.

The lengths of the distal and proximal parts 50, 54, as well as of the center part 52, cannot be precisely defined because this definition is arbitrary. For the purpose of the invention, a length L0.1 of the center part 52 in the upper section 42 is defined by the turning points in which the convex curve section that lies in the xz-plane and contains the maximum 59 transforms into the adjacent concavely curved section that also lies in the xz-plane and contains the minimums 60, 61. In this case, the distal and proximal parts 50, 54 extend from this point to the respective endpieces 48, 55. The position of the turning points is defined in Figure 1 by the position of the cross-sectional planes 49 and 51 such that the length L0.1 of the center part 52 of the first section 42 is equal to the distance between the planes 49, 51. The same distance or a different distance can be used for the longitudinal dimension of the center part of the lower section 43.

In addition, variables A1A-A4A are obtained from Figure 7 (if turned to the left in the xy-coordinate system). These variables are referred to as distance vectors below because they indicate the distances of the minimums (in this case, for example, 60) from the longitudinal axis

39. In this case, these distances may be identical to one another or differ from one another. The sum of the dimensions A1A and A3A results in the height H, and the sum of the dimensions A2A and A4A results in the thickness D of the handle 38, in the sense of the definition according to Figure 2, in the respective cross section A-A. Corresponding distance vectors A1B-A4B and A1C-A4C are obtained for the sectional planes B-B and C-C, wherein the distance vectors A1B and A2B represent the most important distance vectors because they define the shape of the handle 38 in the region that contains the curvature 57 and is encompassed by the palm 33 and the fingers that originate at the palm. The letters A-C, etc., also identify the respective sectional planes according to Figures 7-9 in this case.

The previous description indicates that the aforementioned values (for example, R2.1, L0.1, RB.10, A1B, etc.) are all referred to points in two selected planes that correspond to longitudinal sections through the handle 38 in the xz-plane and the yz-plane. The main reason for this can be seen in the fact that the point 59, which is of particular importance for achieving a preferred coupling position and has the greatest absolute distance from the z-axis, lies, in accordance with this definition, in the xz-plane. It should be clarified that, in addition to the longitudinal sections shown in Figure 5, other longitudinal sections or additional longitudinal sections that lie between the xz-plane and the yz-plane and also contain the z axis can be used for describing the outer surface area of the handle 38. This primarily pertains to the longitudinal sections in the three-dimensional sector of the upper section 42 that contains the surface area section with the curvature 57 (Figure 8), and extends over an angular range between approximately 90° and 135° beginning at the yz-plane.

The arrangement shown represents an optimally designed handle for a right-handed user. An optimally designed handle for a left-handed user would have a shape that, by comparison to the described handle 38, extends in a laterally reversed fashion referred to the xz-plane. For right-handed users and left-handed users, the handle would be designed symmetrically, referred to the xz-plane. This arrangement does not provide an equally superior contact area for the fingers, as does the asymmetrically designed handle 38. However, the design for right-handed users already provides left-handed users with a superior contact area for the hand, by comparison to handles currently available on the market. If a handle for right-handed users and left-handed users, respectively, should be provided, it may also be practical to arrange asymmetric sections, in particular, in the region of the distance vectors A2A, A4A, A2B, A4B, etc.

The handle 38 described above with reference to Figures 5-10 is centered in the hand cavity approximately in the center of its longitudinal extent. The ball of the hand root and the ball of the hand edge respectively contact the upper sections of the distal and the proximal parts. Handles of this type are primarily suitable for light hammers, small mason=s trowels and similar hand and garden tools. An imaginary longitudinal axis of the hand assumes a very steep or nearly

a right angle, referred to the longitudinal axis 39 of the respective handle 38, in the preferred coupling position. All these handles are realized in the form of one-piece handles.

Figures 11-13 indicate how the handle 38 is, when using, for example, a hammer 64, initially taken hold of by the human hand 19, from the side of the upper section 42, and subsequently encompassed. Figures 11-13 show the position for a right-handed user, with Figure 11 showing the preferred coupling position of the hand while using the hammer 42. A broken line 65 indicates the approximate position that the convex curvature 57 shown in Figure 8 assumes in the hand 19. Figures 12 and 13 schematically show two hand positions in the form of sections viewed from the distal end, in a position that is, referred to Figure 8, turned by approximately 180° about the z-axis, and show the trapezoidal shape of the index finger joints 23, 24 and 25, shown in Figure 3, in connection with the position of the thumb 20.

Conventional handles according to the prior art do not fill the cavity of the hand encompassing the handle, and do not sufficiently support the hand, such that twisting motions occur. The handle according to the invention is, by contrast, shaped such that a nearly complete support and a very uniform pressure distribution are achieved, and that the handle "snugly" fits against the respective hand regions at all locations. Practically, the hand encompassing the handle should automatically assume a predetermined coupling position that is perceived as comfortable and favorable by the user, and is referred to as the "preferred coupling position" in this context. However, the handles are neither individually adapted to a certain hand nor designed for an "average hand," but rather are dimensioned in accordance with "groups of hand sizes" that are obtained from hand measurement data, as well as by sensible sorting and classification thereof.

According to the invention, these dimensions and shapes of the handles are adapted to one another in such a way that the resulting handle shape and handle size automatically predetermine a preferred coupling position of the hand for the entire associated group of hands, and that the handle is perceived as lying comfortably in the hand by users of this group when the respective tool is used, and also when higher forces are introduced or when the tool is subjected to permanent use, due to the uniform pressure distribution. This [invention] is, in particular, intended for professional use of the respective tool by craftsmen and causes, if at all, the least possible fatigue and pain in the hand or the arm. Among other things, this is achieved due to the fact that, according to Figure 4, the dimensions L0.1, LI.1, LII.1 and LIII.1 that are shown in this figure and are described above with reference to Figures 5 and 6, as well as the corresponding dimensions that lie in other sectional planes, are essentially realized in accordance with the shape of the hand. In this case, the dimension L0.1 is essentially defined by turning points in which the concave hand cavity transforms into the convex curvatures of the thumb bridge 26 on one side and the ball of the hand edge 31 on the other side. The dimension LI.1 is defined by the distance between the center of the hand cavity and the highest region of the thumb bridge 26, and the

dimension LII.1 is defined by the distance between the center of the hand cavity and the highest region of the ball of the hand edge 31. The dimension LIII.1 of the handle is defined by the distance between the center of the hand cavity and the hand edge 30 that needs to be supported on the proximal part in Figures 5-10.

Figure 12 shows a highly abstract section through the handle 38 and the hand 19, of a right-handed user, which encompasses said handle. The contact region between the palm 33 and the fingers and the circumference of the handle 38 is illustrated in the form of sectors in a left-rotating angular coordinate system. The angular coordinate plane of 0°-180° corresponds to the xz-plane and the angular plane of 90°-270° corresponds to the yz-plane of the cartesian coordinate system in Figures 5 and 6. In this case, the longitudinal axis 39, or the z-axis of the handle 38 according to Figures 5 and 6, extends through the point Z.

Figures 12 and 13 also show that the fingers that encompass the handle 38 laterally and on the underside press in the direction of the palm 33, as well as in the direction of the inner side of the ball of the thumb 28. The balls of the hand edge 31 laterally adjoin the proximal part 54 of the handle 38. The inner side of the ball of the thumb 28 lies approximately along an angular range of 315°-0°, as is schematically illustrated in Figure 12 by a segment 67 that represents the contact surface and is illustrated on an excessively large scale. The palm 33 adjoins the handle along an angular range of approximately 0°-135°, which is indicated in the form of a segment 68, with the middle finger shown in Figure 12 adjoining the handle 38 along an angular range of 135° up to slightly more than 270° (segment 69) analogously to the ring finger and the little finger. For a left-handed user, the angular ranges would extend in the opposite direction of rotation.

Figure 13 shows that the handle 38 adjoins the inner side of the fingers with its lower section 43 that has a comparatively small curvature radius (e.g., RB.12 in Figure 8), wherein said fingers form an approximately trapezoidal inner line with their joints in the encompassing position. This figure also shows that the thumb 20 adjoins, below its middle joint, one side of the handle 38, and that the index finger adjoins the handle 38, on the other side, with its inner side below the first joint. Both fingers laterally exert pressure upon the handle in the contact regions such that the handle is guided by the fingers. The contact regions subjected to pressure are illustrated in Figure 13 in the form of hatched segments 70, 71. The thumb bridge 26 exerts only a little pressure upon the handle 38, and merely adjoins the handle with its thin tissue 72 such that no tension in the bridge tissue occurs. However, this region of the hand is still in adequate contact with the handle 38. A broken line 73 in Figure 13 indicates an invisible part of the handle 38 within the region of the greatest height and thickness (curvature 57 in Figure 8).

Tests on the pressure resistance of the hand surface demonstrated that a "soft" spot lies in the boundary region between the ball of the thumb 28 and the palm 33. At a uniform specific

pressure, this region will yield more than the palm 33. Consequently, the curvature 57 (Figure 8) is at its greatest at this point in an ergonomically correct handle, in order to achieve a uniform load distribution over the entire surface of the hand curvature.

According to the invention, the handle shapes and handle sizes are based on the notion that, in particular, the dimensions L0.1, LI.1, LII.1 and LIII.1 according to Figure 5, and the analogous dimensions in the other longitudinal sectional planes, are important for achieving an appropriate "fit" and the preferred coupling position. This applies, in particular, to the contact region of the ball of the thumb 28 and the hand cavity that lies between approximately 315°-135° in the angular coordinate system according to Figure 12. This concept is taken into account in the form of the distinct curvature 57 in the center part 52 of the upper section 42 of the handle 38 in at least two planes that extend perpendicular to one another, i.e., in the angular range between 0° and 90° referred to Figure 12. The progression of the curved surfaces of this curvature 57 in the longitudinal direction and the circumferential direction as they are approximately defined by the radii RB.10 and RB.11 (Figure 8) is also important. In addition, the lengths of the respective distance vectors beginning at the point Z of the respective cross sections are also important, with the lengths of said distance vectors being defined, for example, by the values A1B and A2B in Figure 8.

The radius in the lower section 43 of the handle 38 that is adjoined by the fingers is also important for achieving a comfortable feel of the handle. The fingers that adjoin the handle and are bent at the joints form a trapezoidal contour on their inner surface. The radius or the arc of the handle cross section in this region needs to be dimensioned such that it is tangent to the trapezoidal contour over the longest distance possible, and the contact pressure is distributed over the largest possible surface of the fingers. This requirement should also apply if the position of the finger joints changes slightly, for example, due to changes in the hand position, or with hands that have fingers of different length. The proximal finger joints that adjoin the lower side of the handle form a slightly curved contour that extends in the transverse direction of the hand when it encompasses the handle. Accordingly, the curvature on the lower side of the handle that is identified by the radius R2.3 is only slightly curved, i.e., it has a large radius. The central and distal finger joints adjoin the outer side of the handle in the region of the lower handle part 43 and part of the central handle part 44. The inner contour of these finger joints is also slightly curved in the transverse direction of the hand on this side, as indicated by the radius R2.4 in Figure 6, if the handle has an optimal ergonomic design. However, the handles could also be shaped such that a compromise between the optimal design for right-handed users and a relatively adequate shape for left-handed users is achieved. In this case, the radius R2.4 is smaller, i.e., the side is curved more strongly. In any case, the curvature is smaller than the

curvature on the opposite side that is defined by the radius R2.2, and is smaller than the curvature on the upper side that is defined by the radius R2.1.

For the purpose of the invention, existing anthropometric investigations, as they are published on page 231 of Research Report 156 by the German Federal Institute for Occupational Safety and Accident Research of 1979, were used as the basis for deriving the dimensions L0, LI, LII and LIII. Initially, three groups of hand sizes were specified: "S" = "small," "M" = "medium" and "L" = "large." Hand sizes up to the 20th percentile were categorized as "small," hand sizes between the 20th and the 75th percentile were categorized as "medium," and hand sizes up to the 100th percentile were categorized as "large." According to the invention, it was determined that the dimension L0.1 according to Figure 5 should approximately amount to 50%, preferably 45%-55%, of the average hand width according to dimension B in Figure 3. In addition, the dimension LII.1 according to Figure 5 should approximately amount to 33%-37% of the average hand width B, and the dimension LIII.1 should approximately amount to 50%-55% of the average hand width B. This results in a LIII.1 value of approximately 47 mm-60 mm for the hand sizes "S" through "L." If this is weighted with the hand widths found in the cited investigation, the length L0.1 amounts to approximately 43 mm for small hands (S), approximately 46 mm for average hands (M), and approximately 48 mm for large hands (L). Based on these core measurements, the remaining measurements of the handles were determined empirically based on models and group tests, wherein the desire for standardization was also taken into account. Different finger lengths as they were found on hands of identical width were consequently not taken into consideration in the design and the dimensions of the handles.

The handle size essentially is adapted to the various hand sizes within the dimensional ranges LI and LII, wherein the total length of the handles preferably remains the same. The distal and the proximal endpieces 48, 55 are adapted in the form of continuous progressions that extend up to the handle ends in the cross sections occurring in the end points of the handle 38. In handles that contain a thumb support in the distal region, the total length of the handle is preferably also changed in order to adapt the handle to the hand size.

Surprisingly, it was determined that handles with the above-described characteristics and dimensions are suitable for various tools. Depending on the respective function, only comparatively slight changes in the basic shapes are required. This means that at least the center parts 52 of the upper sections 42 are realized very similarly with respect to their size and shape. Depending on the intended use of the respective tool, different shapes are, in particular, practical in the region of the distal endpieces 48 of the handles 38. In certain respects, this also applies to the proximal endpieces 55. Depending on the type and size of the tool on which the handles 38 are used, it is practical to vary the height H and the thickness D or the length of the distance

vectors. However, the contour that adjoins the hand is very similar in handles 38 that are used for various tools.

In order to achieve a superior fit of the handle 38 in the hand cavity or a shape that is largely adapted to the hand cavity, the parts 50, 52 and 54 in the upper section 42 are, according to the invention, considered to be particularly important as described explicitly with reference to Figures 11-13 (the adjacent sides of the section 44 are also considered to be important, but this section is omitted in this case because the entire upper part of the handle is assigned to the section 42 and the entire lower part of the handle is assigned to the section 43). Consequently, the shapes and dimensions are adapted at these locations in such a way that the preferred coupling position is assumed almost automatically by all hands of the respective group of hands, due practically only to the upper section 42.

The surfaces of the inner section 44 (Figure 8) of the handle 38 are also curved convexly outward in this embodiment (Figures 7-10) in order also to provide a superior support surface for the hand in this region. In addition, the surfaces of the sections 42 and 43 are realized continuously, i.e., the transitions between the various surfaces of the sections 42, 43 and 44 are preferably continuous and smooth, such that the convexly curved center part 52 gradually transforms into the parts 50 and 54 that are curved concavely inward.

In this embodiment, the lower section 43, which is situated diametrically opposite to the upper section 42 and lies below an imaginary central plane (= yz-plane) of the handle 38 in Figure 5, is shaped and dimensioned similarly to the upper section 42. This lower section is rounded, in particular, in the shape of an egg, and contains no corners or edges that press against the fingers (Figures 7-10).

In order that the preferred coupling position of the hands of an associated group of hands is not only automatically assumed, but practically becomes mandatory due to the design of the handle, selected dimensions of the handle 38 can be further defined based on experience and investigations as deemed practical for a coupling position, in particular when handling a hammer. For example, the parts 50 and 54 may ascend less concavely than in Figure 5 from the minimums 60, 61 (Figure 5) in the proximal and in the distal direction, or even be flat or plane. In this case, the minimums 60, 61 are those points that have the greatest distance from a chord drawn through the end points of the parts 50 and 54. However, a continuously concave progression of the parts 50 and 54 and the corresponding parts in the remaining handle sections provides the significant advantage that the handle 38 fits the hand in an almost positive fashion, such that its tendency to slide in the direction of the longitudinal axis 39 is reduced when using the tool.

Other important dimensions for the purpose of the invention are the curvature radii, in particular, the radius R2.1 and R2.2 (Figure 5) which, depending on the hand size, lies between 50 mm and 120 mm. These dimensions essentially define the convex curvature in the

longitudinal direction. Another important dimension is the radius R22 in the yz-plane. This radius defines part of the longitudinally extending curvature in the second direction. This applies analogously to the longitudinally extending radii in the transitions between the xz-plane and the yz-plane, for example, the radius R2.5.

Other important dimensions are the radii RA.10-RA.13, RB.10-RB.13 etc. and, in particular, the radius RB.10 and RB.11. This radius defines the progression of the curvature 57 (Figure 8) in a second direction (y-axis and yz-plane, respectively) such that the curvature 57 is pronounced in two directions that extend perpendicular to one another. In a handle 38 for left-handed users, the radius RB.13 would have to be dimensioned accordingly in order to make the curvature more distinctly pronounced toward the right side in Figure 8.

In addition, the total thickness D and the total height H of the handle 38 are naturally important in this context. Figures 7-9 indicate that the distance vectors A1A-A4A, A1B-A4B etc. may respectively be identical or different in the x-direction and the y-direction.

In handles 38 that are realized symmetrically referred to the xz-plane and/or the xy-plane, the corresponding values A1A-A4C may be identical (e.g., A1B = A3B and/or A2B = A4B), and can consequently be replaced with the dimensions H and D. It is also preferred to predetermine identical values at least for the dimensions L0.1 of the handles for a preselected group of hands, with the dimensions R2.1 lying close to one another. It is preferred to carry out a weighting in such a way that, for example, the different dimensions of the distal part 50 are defined in order to realize the preferred coupling position in accordance with the above-described dimensions, with the dimensions of the proximal part 54 and, if applicable, the proximal endpiece 55 being of lesser importance in this case.

With respect to the dimensions LI.1 and LII.1, it may be advantageous to choose approximately identical values for these dimensions for most handles, i.e., the maximums 59 are arranged in the xz-plane in the center between the corresponding minimums 60 and 61. However, there may also be instances in which the maximums 59 are not arranged exactly in the center, but rather are offset toward the distal end or the proximal end. In addition, the distal and proximal parts 50, 54 of the handles 38 usually have approximately the same length so that the center parts 52 lie essentially in the center between the two adjacent distal and proximal parts 50, 54.

It is also important for the invention to standardize a series of the above-described dimensions R, L, A, H and D, and to predetermine essentially identical values for a series of hand and garden tools. This is based on the idea that handles of the described type are realized very similarly with respect to size and shape, not only in the central part 52, but also the distal part 50. In such instances, it is merely required to adapt a few of the indicated dimensions, e.g., the distance vectors, as well as the proximal parts 54 and/or the proximal endpieces 55, to the given application (tool type) with respect to their size and shape. This provides the user, particularly the

professional user, with the advantage that various types of tools will have handles of the same basic size and shape, so that the user will easily be able to select suitably fitting handles.

On the distal and/or proximal end of the handle 38, the endpieces 48 and/or 55 are preferably designed in the form of a bulge. This is realized by dimensioning their cross sections to be greater than in the region of the sections A-A and C-C in Figures 7 and 9. In the preferred coupling position of the hand, the outer sides of the finger joints of the index finger and the little finger and, if applicable, the hand edge 30 and the ball of the hand edge 31 are supported on these endpieces 48, 55.

According to Figures 6 and 10, the handle 38 may also be provided with a support surface 74 for the thumb 20. This support surface 74 preferably lies on the upper side of the distal endpiece 48 and a region of the distal part 50 situated adjacent thereto. Figure 10, in particular, shows that this support surface may consist of a trough or flattening that extends parallel or slightly oblique relative to the yz-axis.

Another preferred embodiment of a handle 78 is shown in Figures 14-18. This handle 78 essentially differs from the handle 38 only in that a support surface 80 is arranged on the surface of the center part 79. Specifically, the cross section in Figure 17 indicates that this support surface is arranged on the side of the xz-plane which faces away from a curvature 81, wherein the curvature 81 corresponds to the curvature 57 in Figure 8. According to Figures 14 and 15, the support surface 80 may also extend over a larger region or even the entire region of the center part 79 in the direction of the longitudinal axis 82 of the handle 78. In other respects, the support surface 80, like the support surface 83 for the thumb, is essentially realized to be flat or slightly concave, i.e., in the form of a groove or trough that extends in the direction of the longitudinal axis 82. This support surface is provided in addition to or instead of the support surface 83. The support surface 80 advantageously serves for supporting the ball of the thumb 28 in order to achieve an even better adaptation to the hand and an even more comfortable coupling position.

The most important dimensions for a preferred embodiment of the handle 78 according to the invention are indicated in the tables shown in Figures 93a and 93b. The dimensions listed in these tables indicate in two columns [sic] the dimensions specified for a given group of small, medium and large hands. The dimensions for a medium hand "M" fall between the values for "S" and "L," wherein intermediate sizes may also be provided if so required. According to the invention, a total of three groups, namely, "small," "medium" and "large," is considered sufficient. A more detailed explanation of Figures 93a and 93b is provided below.

In the embodiment according to Figures 19-24, the handle 86 is intended for a tool in the form of a mason=s trowel, which is not illustrated in these figures. The handle 86 essentially corresponds to the handle 38 according to Figures 5-10, where said handle comprises a support surface 87 for the thumb, as in Figures 6 and 10. A distal handle end lies in a plane 89 that

extends perpendicular to a longitudinal axis 88 of the handle 86, with the distal endpiece 90 ending in the aforementioned plane. As in the previous description, one respective distal part 91, one center part 92, one proximal part 93 and one proximal endpiece 94 are situated adjacent to this endpiece 90.

The values for the various dimensions are chosen so that the handle 86 is also suitable for other tools besides mason=s trowels, e.g., heavy hammers, roofing hammers, sledge hammers, axes and, in an analogous two-part design, for garden and pruning shears. The important dimensions for a preferred embodiment of the handle 86 are indicated in the tables according to Figures 94a and 94b. This applies, in particular, to the length L0.1 of the center part 92 arranged between the two cross-sectional planes 95, 96 which is measured in an upper section and approximately corresponds to 50% of the hand width of the assigned group of hands, as well as to the dimensions LI.1 and LII.1 that define the position of the minimums 97, 98 of the upper surface contour in the distal and the proximal part 91 and 93. The position of a reference plane 95 is defined by the maximum 100 of the center part 92 in Figure 5. In other respects, the handle is designed essentially identically to the handle according to Figures 5-10.

Figures 25-30 show a second embodiment of the handle 86 according to Figures 19-24, wherein the same reference symbols were used for designating identical components. In addition to the support surface 87 provided on the upper side of the upper section, a second lateral support surface 101 for the thumb 20 is provided in this case. This second support surface lies in the distal part 91 of the handle 86 analogous to the support surface 87 and preferably extends into the distal endpiece 90. The cross sections in Figures 27 and 30, in particular, indicate that the support surface 101 is arranged on the side of the xz-plane which faces away from the curvature 102, where said curvature 102 corresponds to the curvature 57 in Figure 8. The support surfaces 87 and 101 may essentially be realized flat or slightly concave so that they are adapted to the shape of the thumb. Figures 27 and 29 show that the support surface 101 may extend from an upper section 103 of the handle 86 into an adjacent inner or central section 104 that can also be assumed to be omitted in its entirety. The lateral support surface serves for achieving an additional lateral guidance of the handle. A similar lateral support surface may also be provided on the handles for hammers which are shown in Figures 5-6 and Figures 10-18. In other respects, the handle is designed essentially identically to the handle according to Figures 19-24.

Figure 31 shows the handle 86 in connection with a mason=s trowel 105, namely in the position in which it is grasped by the hand 19 of a right-handed user in a first preferred coupling position. In this case, the thumb 20 rests on the upper support surface 87. Figure 32, in contrast, shows the handle 86 of the mason=s trowel 105 in the position in which it is held by a right-handed user in a second preferred coupling position. In this case, the thumb 20 adjoins the lateral support surface 101, which is not visible in Figure 32.

The handles 38, 78 and 86 according to Figures 5-32 are particularly suitable for tools 64, 103 in which the hand encloses the handle from the top in the preferred coupling position. Figures 33-37 show a handle 106 for a tool that is pushed and pulled, i.e., a saw 107 or, for example, a handplane, a firmer chisel (wood chisel) or the like. According to Figures 33-37, the handle 106 of the saw 107 is mounted on a functional part 108 by means of screws or the like. The handle 106 is provided with a central opening 109 as is customary, for example, with straight-back handsaws with open handles. This handle is provided with an upper section 110 (on the right in Figure 36) that contains support surfaces for the inner side of the hand on the side of the handle 106 which faces away from the functional part 108 or the opening 109, namely analogous to Figures 1, 2 and 5-32. A lower section 111 of the handle 106 (on the left in Figure 36) which faces the opening 109 is provided with support surfaces for the fingers. The sections 110, 111 and a section 112 (Figure 17) situated between the two aforementioned sections correspond to the sections 7, 8 and 9 in Figures 1 and 2. A handle for a bow saw or the like may be realized accordingly.

A comparison between Figures 5-9 and Figures 33-37 shows that the surface contours of the sections 110, 111, as well as of the inner section 112 (Figures 36) that connects the two aforementioned sections, are realized largely identically to the sections 42-44. In addition, the handles 38, 78, and 86 each comprise a distal endpiece 114, a distal part 115, a center part 116, a proximal part 117, and the proximal endpiece 118, which are arranged one behind the other in the direction of the longitudinal axis 119 (Figure 34), analogously to the handle 106. The cross-sectional plane B-B which extends through a summit or maximum 120 of the surface contour of the center part 116 in the upper section 110 again serves as the reference plane. The length of the convex center part 116 is defined by the position of the turning points to the adjacent concave parts 115, 117 and by cross-sectional planes 121, 122 that extend through these turning points, with the length of the convex center part being dimensioned at approximately 50% of the hand width B (Figure 3) of the average user of the assigned group. The position of concave minimums 123, 124 of the distal and the proximal part 115, 117 is respectively defined by the dimensions LI.1 and LII.1, with the values of these dimensions being identical to those in Figures 5-10.

In other respects, the previous explanations regarding the handles 38, 78, and 86 also apply in this case, with the various dimensions being indicated in the tables according to Figures 95a and 95b. In addition, Figures 38 and 39 indicate how the handle 106 is initially taken hold of from the rear and then enclosed with the human hand 19 while the saw 107 is used. The position for a right-handed user is illustrated in Figures 38, 39, with this position simultaneously representing the preferred coupling position of the hand while using the saw 107.

The handles 38, 78, 86 and 106 described thus far are explained in greater detail by means of side views and top views, as well as a few cross sections that extend perpendicular to their longitudinal axes (e.g., Figures 27-30). In this case, the side views and top views respectively show an outer contour in the upper end of the lower region which has the shape of a concave-convex-concave curve 127, 128 (Figure 25) and 129, 130 (Figures 26). This outer contour would also result if a longitudinal section that contains the z-axis and lies in the xz-plane would be illustrated in Figure 25 instead of the side view shown, and if a corresponding longitudinal section that lies in the yz-plane would be illustrated in Figure 26. Consequently, each of these curves 127-130 represents a (usually different) generatrix of the surface area of the handle body, wherein the handle body would represent a body of revolution with the z-axis as the axis of rotation if all curves 127-130 were identical. For example, Figures 25 and 26 show that one particularity of the invention can be seen in the fact that the curves 127-130 may have entirely different progressions because the handles designed in accordance with ergonomic requirements largely have an asymmetric shape.

In the previous description, it was assumed that the cross sections, e.g., according to Figures 27-30, are essentially egg-shaped or oval or elliptical, except for possibly provided support surfaces 87, 99 in order to simplify the illustrations. In this case, the respectively largest diameter lies, according to Figures 1 and 2, on a line that extends parallel to the x-axis, with the respectively smallest diameter lying on a line that extends parallel to the y-axis. Consequently, the described maximums and minimums (e.g., 97, 98, 100 and Figure 25) lie in the xz-plane. This means that the curve 127 extends in one plane. This applies accordingly to the curves 128-130, wherein the curves 129, 130 lie, however, in the yz-plane. In addition, it was assumed in the previous description that the maximums (e.g., 100 in Figure 25, but also 59 and 120 in Figures 5 and 33) define the point on the surface area of the handle body which has the greatest absolute distance from the respective z-axis (e.g., the dimension A1B in Figure 22). This is the reason the curve 127 represents the geometric locus of all points on the surface area of the handle body which respectively are the greatest distance from the z-axis along the latter, and thus forms a generatrix of the surface area which always has a convex progression in the region of the curvature 102 and, according to the invention, respectively lies in the upper section 42 or 102.

Except for the position of the curvature 102 in the upper section 42 or 102, these prerequisites are neither absolutely imperative nor always advantageous with respect to ergonomic aspects. It may, in particular, be practical to shift the point that has the greatest distance from the z-axis into a plane which is arranged parallel to the xz-plane that always represents the central plane in this case. This, among other things, makes it possible to achieve an improved adaptation of the handle 86 to the cavity of the hand 19, in particular, due to a more pronounced lateral excursion of the curve 102 (Figure 28). For reasons of simplicity, it may also

be specified in this case that the curve containing the absolute maximum represents a curve that lies in a plane that extends parallel to the xz-plane. It would, in contrast, also be possible for the curve containing the absolute maximum to represent the geometric locus of all points that are the greatest distance from the z-axis along the latter. This means that this curve may also represent a three-dimensional curve that only lies on one side of the xz-plane or contains points that lie on both sides of this plane. This is described in greater detail below with reference to Figures 40-45.

Figures 40-43 show longitudinal sections through a handle 131, the outer contour of which essentially corresponds to the previous description. Figure 40 shows a longitudinal section in the xz-plane which contains the z-axis such that the contours essentially correspond, for example, to those in Figure 25. Figure 41 also shows a longitudinal section that contains the z-axis, but this longitudinal section corresponds to a sectional plane that extends from 45° to 225° in the angular coordinate system shown in Figure 12. Figure 42 shows a longitudinal section in the 90°-270° position according to Figure 12, and Figure 43 shows a longitudinal section that contains the z-axis, analogously to the remaining longitudinal sections and extends from 135° to 315° in Figure 12. The three longitudinal sections shown in Figures 41-43 can also be assumed to be generated by incrementally turning the handle 131 by 45°, starting from the position shown in Figure 40 and then sectioning the handle parallel to the plane of projection.

Figure 44, based on Figure 40, shows a total of 20 cross sections that extend perpendicular to the z-axis. This means that the x-axis of the imaginary coordinate system points vertically upward in all sections. If all sections shown in Figure 44 are arranged one behind the other on the z-axis at the distances indicated in Figure 40, their circumferential lines 132 (see cross section A in Figure 44a) very closely represent the surface contour of the complete surface area of the handle 131 when connecting all circumferential lines 132 to one another over the shortest possible distance by means of conical surfaces. The accuracy of the thereby obtained surface area is improved as the number of cross sections used increases.

According to the present invention, it is important that the upper section that contains the curvature and that is identified by reference symbol 103, analogously to Figure 28 (see cross section A in Figure 44a), contain not only points that lie in the xz-plane but also points 133-143 that are the greatest distance from the z-axis in the respective cross section and at least partially do not lie in the xz-plane. The distance vectors 144-154 which lead to these points 133-143 are respectively indicated in Figures 44a and 44b in the form of arrows. This indicates that the radius vectors 144-154 partially extend on the right side of the xz-plane and partially on the left side of this plane similar to spatial vectors. In this case, the angles a (see cross section H) formed in connection with the xz-plane precisely indicate in which longitudinal sectional plane that is formed as in Figures 40-43 and includes the z-axis the points 133-143 lie. Here, all points 133-143 theoretically may lie on different longitudinal sections.

The radius vector 147 in the cross section K has the absolute greatest length of all radius vectors that are shown in Figure 44 and that lie within the region assigned to the central part (see, for example, the cross sections H-R). Consequently, the point 136 defined by this radius vector has the greatest distance from the z-axis within the central part in the upper handle section, with this point corresponding, for example, to the maximum 100 in the illustration of Figure 25. In addition, Figure 45 shows that the points 133-143 which are connected by the curves 155 and 156 have partially positive and negative y-values in the xyz-coordinate system shown in Figure 12. However, all x-values are positive and have their minimum in the cross section L such that they lie on a three-dimensional curve.

In contrast to Figures 40-44, it is also possible to locate the points 133-143 so that they all lie on the same side of the xz-plane, but at a certain distance from this plane. The shape selected for an individual instance largely depends on the location at which the different maxima and curvatures lie and how pronounced these maxima and curvatures should be.

With respect to the dimensions L0.1, LI.1, LII.1 and LIII.1 that were described with reference to Figure 5, only a few modifications were made in the arrangement according to Figures 40-45. If the points that have the greatest distances from the z-axis lie on a curve that is located in a plane that includes the z-axis, the xyz-coordinate system is simply turned about the z-axis by such an angle that the xz-plane corresponds to the plane containing the plane curve. The new coordinate system obtained thereby is then used for defining the various dimensions analogous to the previously described coordinate system, with a reference plane that corresponds to the reference plane 63 (Figure 5) and is arranged perpendicular to the z-axis being located, in particular, through the point with the greatest absolute distance from the z-axis. Consequently, the only difference can be seen in the fact that the new xyz-coordinate system assumes a different position in space than the coordinate system in Figure 5.

If the points 133-143 in Figures 44 and 45 would lie in one plane and this plane would not contain the z-axis, but is, for example, arranged parallel to the xz-plane, the coordinate system according to the previous description may be turned in a such a way that the point 136 with the greatest absolute distance from the z-axis lies in the turned xz-plane. When using the aforementioned definitions for the dimensions L0.1, LI.1, LII.1, LIII.1 etc., slightly different values than those determined in the plane that contains all points 133-143 would be obtained. This applies correspondingly if the points 133-143 do not lie on a plane curve, but rather on a three-dimensional curve analogous to Figures 44, 45, and if a plane that contains the z-axis and the point 136 is used as the new xz-plane. In such instances, the positions of the maxima and minima determined in accordance with Figures 5-10 and the values for the dimensions L, R, A etc. slightly deviate from the actual values. However, the deviations become smaller as the distance of the maximum 136 from the xz-plane decreases (see, for example, Figure 45) such that

the definitions outlined above with reference to Figures 5-10 can be used here for achieving a superior approximation. This is the reason the value ranges indicated in the tables according to Figure 93a-Figure 96c also include handles in which the maximum (e.g., 59 in Figure 5) lies on a three-dimensional curve and/or not in the described xz-plane. In other respects, the cross section K in Figure 44a schematically indicates in which sectional planes of the longitudinal sections according to Figures 40-43 appear. In this case, a longitudinal section L1 is referred to as a section in the xz-plane (a = 0°), and a longitudinal section L2 is referred to as a section in the yz-plane (a = 90°). Accordingly, L3, L4 and L5 refer to longitudinal sections with the angles a = 180°, a = 270° and a = 45° which include the z-axis, namely viewed in the directions of the respective arrows. These longitudinal sections L1-L5 are also indicated in the table.

The tables according to Figures 94a, 94b contain numerical values in millimeters for a handle that is designed in accordance with Figures 40-45 and Figures 19-24, wherein the longitudinal sections L1-L5 in column 1 of Figure 94a correspond to the longitudinal sections at angles of 0°, 90°, 180°, 270° and 45° in accordance with the representation in section K of Figure 44. Column 2 contains the three selected groups of hands, column 3 contains the corresponding hand widths B, and column 4 contains the handle lengths, for example, between the planes 45 and 46 in Figure 5. The lengths and radii according to the definitions indicated in Figure 5 are contained in columns L0-LIII and R1-R3, wherein, for example, the dimension of 41 mm (handle size "M") that is formed by the combination of L2 (column 1) and LII (column 7) means that this length LII is contained in the longitudinal sectional plane L2 and corresponds to the dimension LII.2 in Figure 5, although in the corresponding sectional plane. In this case, the value formed from L1 and LII corresponds to the value LII.1 drawn in the xz-plane in Figure 5. This means that all important dimensions for the handle according to Figures 40-45 can be obtained from the tables. Accordingly, the dimension R2 (next to the last column in Figure 94 a) indicates, for example, in connection with L2 that this pertains to the radius R2.2 in Figure 5.

Corresponding dimensions for the radii R10-R13 are indicated in Figure 94b, wherein R10 in column K corresponds, for example, to the radius RB.10 in Figure 8 because it lies at the maximum (see cross section K in Figure 44a). Accordingly, the dimension A2 in the sectional plane K represents the dimension A2B in Figure 8.

Figures 46-50 show grid representations of a handle 157 in which the points with the greatest distance from the z-axis lie on a three-dimensional curve that extends in the longitudinal direction of the handle 157 analogous to Figures 40-44. In this case, the distal end is respectively arranged on the left and the proximal end is respectively arranged on the right. The handle 157 in Figure 46 is illustrated in the form of a perspective presentation, with Figure 47 showing a side view analogous to the illustrations in Figures 5, 14 and 19, namely a view from the right side of the handle 157 or from the distal end. Figure 48 shows a top view, Figure 49 shows a side view

from the opposite side, and Figure 50 shows a bottom view of the handle, with these views resulting by respectively turning the handle 157 90° about a longitudinal axis 158 starting with Figure 47. In the preferred instance, the left side again represents the side that is provided with a pronounced curvature 159 that extends in at least two directions.

The handles (e.g., 38) described thus far are respectively realized in one piece, wherein the first sections (e.g., 42) are integrally connected to the second sections (e.g., 43) by means of adapted inner sections (e.g., 44). However, the invention is not limited to handles of this type, but may be analogously realized in two-part handles with arms that can be moved relative to one another, e.g., handles for pliers, scissors or the like. As in Figures 1 and 2, in the following description, one of the two handle arms is referred to as the first section and the other as the second section, with the two arms or sections being separated from one another by an intermediate space, in contrast, for example, to Figures 5-10, so that the two arms or sections are not physically connected to one another.

When designing handles for pliers, it is important that all four distal finger joints 25 (Figure 3) adjoin the surface of the second, lower section as uniformly as possible when the pliers are in the open position, e.g., before cutting a wire or before surrounding an object with the serrated jaws of universal pliers, in order to be able to exert a sufficient force. However, the surfaces of this section should adjoin the central finger joints 23 when the pliers are closed.

Figures 51-55 show a handle 160 according to the invention, which, for example, is intended for adjustable gripping pliers. In this case, a handle arm or upper section 162 is realized analogously to the first or upper section of the handles described thus far (e.g., 42 of 38) on its outer surface, with the other handle arm or lower section 163 being realized analogously to the second or lower section of the handles described thus far (e.g., 43 of 38) on its other surface. The two sections 162 and 163 are realized on both sides of a central plane (yz-plane) that extends through a longitudinal axis 164. In order to make it possible to selectively use the pliers in two positions that are turned about the longitudinal axis 164 by 180° and to achieve approximately the same preferred coupling position relative to the hand cavity and the ball of the thumb, the lower side of the lower section 163 in Figure 51 is realized with the same shape as the upper side of the upper section 162, but in a laterally reversed fashion relative to a central plane (xy-plane). Thus, the underside of the section 163 or 162 which respectively lies on the bottom when the given tool is used does not provide optimal contact surface for the fingers. Since the upper sides of both sections 162, 163 which are of particular importance for the invention have identical shapes, only the design of the upper section 162 in accordance with the invention is described in greater detail below. In this case, the central plane is preferably placed so that it contains a not-shown rotational axis that connects the two arms of the pliers to one another, with this

rotational axis extending perpendicular to plane of projection in Figure 51 and consequently parallel to the y-axis in the sense of the definitions used thus far.

According to Figures 51 and 52, the upper section 162 is provided with a surface contour 165 and is divided into a distal part 168, a central part 169 and a proximal part 170 that are arranged one behind the other in the longitudinal direction by means of imaginary planes 166, 167. According to the invention, the section 162 is shaped and dimensioned in such a way that the central part 169 is situated in the hand cavity in the conventional coupling position of the hand for universal pliers, with the distal part 168 being encompassed by the thumb bridge 26 and the proximal part 170 serving as a contact surface for the ball of the hand root 29 and the ball of the hand edge 31. Consequently, the central part 169 has a pronounced convex curvature 171 that is directed outward in the longitudinal direction and in the transverse direction, wherein the distal part 168 is tapered beginning at the center part 169 and continuing to a collar 172 that prevents the hand from sliding off the handle and is arranged on the distal end. The outer contour of the distal part 168 is realized in a lateral region 174 in such a way that it extends with a flat concave arc and with a slight angle of inclination relative to the longitudinal axis 164 in the side view shown in Figure 52, with said contour also extending in slightly concave fashion along the upper surface 165 shown in Figure 51, but with a comparatively large angle of inclination relative to the longitudinal axis 164. Similarly, the proximal part 170 extends on the upper surface (Figure 51) at a comparatively large angle of inclination relative to the longitudinal axis 164, but in essentially concave fashion. In a lateral region 175 (Figure 52), its surface extends at a comparatively small angle of inclination relative to the longitudinal axis 164 and essentially in slightly descending concave fashion to the proximal end. On the proximal end, the upper section 162 is preferably hemispherical.

In other respects, the outer contour of the section 162 is dimensioned and shaped in the longitudinal section and in the cross section, as well as in the direction of the handle height H and in the direction of the handle thickness D, such that the other section 163, if realized identically, is sufficiently well adapted to the trapezoidal inner contours of the enclosing fingers in the preferred coupling position. In this case, the curvature 171 in the section 162 is realized in accordance with a curvature 176 in the section 163 that becomes effective after the pliers are turned by 180° about the longitudinal axis 164.

Surfaces 162a, 163a of the sections 162, 163 which face one another are not important for the purpose of the invention, and consequently may be conventionally designed with rounded edges. The handle height H at the different locations along the handle 160 (Figures 53-55) and, in particular, the curvatures were dimensioned in accordance with the assigned group of hands such that a comfortable preferred coupling position is achieved while taking into account the function of pliers.

Figure 56 indicates how the handle 160 is encompassed by the human hand 19 when the pliers are used. This figure shows the conventional position for right-handed users, with Figure 56 showing the initial process of taking hold of the pliers from the rear, Figure 57 showing the pliers being used in connection with the preferred coupling position of the hand, and Figure 58 indicating in a section like Figure 13 how the two sections 162, 163 of the handle 160 are separated from one another and arranged on both sides of the xy-plane in the preferred coupling position of the hand 19. The broken line 177 in Figures 56 and 57 also indicates where the curvatures 171 and 176 shown in Figure 54 are ultimately located on the hand 19.

Analogous to the handle 38, the cross-sectional plane B-B in a maximum 178 in the upper section 162 serves as the reference plane for the handle 160, with said maximum lying in a plane that extends parallel to the xy-plane on one hand and in a longitudinal section that lies in the xz-plane on the other hand.

The length L0.1 of the convex center part 169 is defined by the position of the turning points to the concave adjacent parts 168, 170 and by the cross-sectional planes 166, 167 that extend through these turning points, respectively. Analogous to one-piece handles, this length amounts to approximately 50%, preferably 45%-55%, of the hand width B (Figure 3) of the average user of the assigned group. The position of concave minimums 179, 180 of the distal and the proximal part 168, 170 is defined by the dimensions LI.1 and LII.1, wherein these dimensions may have the same values as those in Figures 5-10.

In other respects, the same explanations as those that refer to the handle 38 apply, with the various dimensions being indicated in the tables according to Figures 96a, 96b.

In an embodiment of the plier handles 183 which are illustrated in Figures 59-63, the upper section and the lower section 184, 185 are, relative to the surfaces that come in contact with the hand cavity and the ball of the thumb in the preferred coupling position, also realized asymmetrically, e.g., in accordance with Figures 61-63. In particular, the lower surface of the section 185 intended for contact by the fingers is realized in a largely cylindrical fashion, when seen in cross section. However, this lower surface only has a slight curvature in the direction of a longitudinal axis 186 (see R2.2 in Figure 59). In this case, the radii and the other dimensions in the lower section 185 are chosen so that this section provides a very comfortable contact surface for the fingers that enclose this section. The "trapezoid" (see also Figure 58) formed by the bent finger joints 23-25 (Figure 3) and the thumb 20 consequently is practically filled by the handle 183 such that a very uniform pressure distribution is possible. The upper section 184 is realized in accordance with the upper section of the handle 160 in Figures 51-55.

The pliers illustrated in Figures 51-63 contain handles 160, 183 for the right-handed user. If the corresponding handles are designed for the left-handed user, the sections 162, 163 and 184, 185 are realized in a laterally reversed fashion relative to the xz-plane (see 61-63).

In other respects, the previous explanations with respect to the handle 160 apply.

Figures 64 and 65 show a handle 189 that contains two sections 190, 191 that are realized in a laterally reversed symmetrical fashion on either side of the longitudinal axis 192 and a central plane (yz-plane) containing this longitudinal axis. Both sections 190, 191 have a clearly pronounced curvature 194 in the sense of the other described handles in a central part 193, namely in the x-direction and in the y-direction. Such a handle shape provides optimal properties for right-handed and left-handed users in the upper section 190 (or 191) that cooperates with the hand cavity. In addition, the handles 189 are significantly improved in comparison to plier handles available on the market within the section 191 (or 190) that is enclosed with the fingers.

Most known plier handles, namely also handles for larger universal pliers or cutting pliers, are simply not sufficiently ergonomic because they do not contain a proximal part with superior ergonomic design or suitable contact surface for the ball of the hand edge. Even the plier handles of larger pliers are too short or extend up to the proximal end in the form of a continuous arc that lies in one plane such that they are by no means adapted to the hand cavity. The entire compressive force consequently must be exerted by the hand cavity. In order to reduce the specific pressure in this region, the invention proposes to extend at least the handles of larger pliers to such a degree that the ball of the hand edge also adjoins a corresponding proximal part (e.g., 170 in Figure 51). Thus, the compressive forces exerted by the ball of the hand edge are provided with a longer lever arm such that the compressive forces acting upon the inner surfaces of the hand are additionally reduced. Consequently, the concave-convex-concave surface contour explicitly described above is also effectively realized in plier handles.

Naturally, other types of pliers, e.g., wire strippers, universal pliers, needle-nose pliers and other gripping and cutting pliers, as well as shears, in particular, plate shears, may be equipped with the described plier handles and other plier handles.

Like Figures 40-50, Figures 66-74 show longitudinal sections, cross sections and grid or dot matrix representations of a hammer handle, e.g., a hammer handle according to Figures 14-18. In this case, longitudinal sections are also illustrated in the four planes 0°, 45°, 90° and 135° (Figures 66-69), with Figure 70 containing a series of cross sections A-L along the z-axis. Practical dimensions for such a section are indicated in the tables according to Figures 93a, 93b which are structured analogously to the tables according to Figures 94a, 94b.

Figures 75-83 show representations that correspond to Figures 66-74 for a saw handle that is approximately realized in accordance with Figures 33-39, and Figures 84-92 show corresponding representations for the upper sections of plier handles, e.g., the pliers according to Figures 51-58. With respect to Figures 84-87, it must be noted that this pertains to an upper section of pliers according to the section 162 in Figures 51-55, and that the position of the longitudinal sections is chosen in accordance with the cross section K in Figure 88a. In addition,

the longitudinal sections, in contrast to the corresponding illustrations (e.g., Figure 40-43), are respectively illustrated in a position that is turned about the z-axis by 180°.

The tables according to Figures 95a, 95b and 96a, 96b indicate the precise dimensions for the saw handle according to Figures 75-83 and the plier handle section according to Figures 84-89, analogously to Figures 94a, 94b.

The invention is not limited to the described embodiments and can be modified in several ways. This applies, in particular, to the individual design of the various handles described with reference to the figures and the dimensions selected for a certain group of hands. An optimal handle for a large hand has a larger total volume than that for a small hand. In addition, other criteria may be used for categorizing the handles into the respective groups, in particular, if dimensions other than those indicated in the figures are deemed practical for ergonomic reasons as the result of a series of tests. With respect to the cross sections, it should be noted that the handles are preferably oval, egg-shaped, circular, elliptical or the like in all regions in which they come in contact with the hand of the user. However, the handles also may have different shapes and, in particular, be provided with conventional finger depressions or the like in the lower sections. In particular, it is possible to select the angular ranges shown in Figure 12 differently, wherein a range of approximately 315°-90° is deemed particularly effective with respect to the angle of the described curvature. However, this does not prevent the handles from containing corners at the locations at which the less-stressed hand sections contact the handle. In addition, the dimensions of the handles in the different groups of hands selected for the purpose of the invention preferably have a ratio of S : M : L = 43 : 46 : 48. This ratio refers specifically to the dimension L0.1, but other group classifications can also be chosen if so required. It is also practical to incorporate the minimum and maximum values for the curvature contours in the region of the various cross sections into the design. For example, the radii R10, R12 preferably have a length between 10 mm and 30 mm while the radii R11, R13 preferably have a length of approximately 15 mm-30 mm. In this context, it is also advantageous to vary the remaining dimensions of the corresponding handle in the same percentile ratio if the sizes are changed from group to group or even within the same group, e.g., if the length L0.1 is changed. A comparison of tables 93a-96c shows that the length of the center part is approximately 50% of the hand width for all described handles. In addition, the curvature radius R2.1 lies between 50 mm and 120 mm and the curvature radii R2.2 and R2.4 lie between 50 mm and 150 mm for all handles. Surprisingly, these dimensions which are particularly important for the coupling position are essentially identical for all handles. The sectional drawings and tables describe examples of several advantageous handle designs. In addition, the scope of the invention not only includes the described handles, but also the tools manufactured with said handles and sets that contain several different handles or tools and that are assigned to the same functional parts. In this case, the sets